MuCap : A Precision Measurement of μp Capture in Hydrogen

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The goal of the MuCap experiment is to perform a high-precision measurement of the rate Λ_S for muon capture on the proton, $(\mu p)_{1S} \rightarrow n + \nu$, by comparing muon lifetimes in the $(\mu^- p)$ and free μ^+ systems. A 1% Λ_S measurement determines the least well known of the weak nucleonic charged current form factors, the induced pseudoscalar g_p, to 7%. Previous g_p measurements have been inconsistent, while recent theoretical advances have yielded an accurate prediction of its value. By employing novel methods we hope to avoid the problematic uncertainties of earlier experiments and resolve the longstanding confusion surrounding g_p.

2003 was a landmark year for MuCap, as it was the first time that all of the major experimental components were assembled and made operational in the μE4 muon beamline at the Paul Scherrer Institut (PSI), Switzerland. Among the developments:

- Our primary muon detector–a new time projection chamber (TPC) constructed expressly for MuCap–was commissioned and reached sufficient voltage to provide 3-dimensional muon tracking information inside the target volume.
- We maintained high purity in the deuterium-depleted hydrogen gas that fills the TPC. This is essential in avoiding distortions to the measured muon lifetime curve.
- A Helmholtz coil was installed around the muon target volume to supply a magnetic field for controlling μ^+ spin rotation.
- One multiwire proportional chamber, ePC1, was fully instrumented with upgraded low-noise front-end electronics. ePC1 provides accurate (ϕ, z, t) information about decay electron passage.
- Berkeley constructed a high-speed data acquisition system (DAQ) to gather data from the various front-end electronics modules.

Figure 1 shows an overhead view of the fall 2003 experimental assembly.

For several weeks in September and October 2003 we recorded both μ^+ and μ^- data, and estimate to have collected roughly 10^9 μ^- events. Although short of the full statistics necessary for a 1% Λ_S measurement, this represents our first substantial production data and should be sufficient for at least a 10% result. Berkeley is currently working on analysis of the 2003 data.

We expect 2004 to be another productive year, with the following anticipated improvements:

- Better materials in the muon entrance path should significantly reduce scattering and increase stopping efficiency.
- The TPC will operate at a higher voltage where Alvarez muons from pμd fusion are visible. This will enable us to make a real-time diagnosis of the hydrogen gas's deuterium content.
- An active gas purification and recirculation system will be installed to further reduce hydrogen gas impurities.
- A recently-constructed second wire chamber, ePC2, will enable enhanced electron tracking.
- Berkeley will upgrade the DAQ for superior reliability and increased data throughput.

With these advances we hope to collect the full 10^{10} μ^- statistics in fall 2004.

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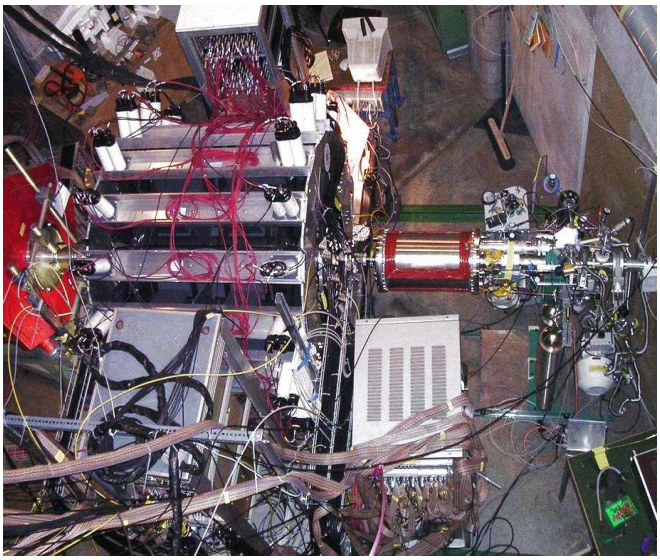

FIG. 1: Photo of the 2003 MuCap experimental setup.